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FURTHER EXPERIENCE IN

ASPARAGUS RUST CONTROL.

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By RALPH E. SMITH.

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FURTHER EXPERIENCE IN ASPARAGUS RUST CONTROL

By RALPH E. SMITH.

INTRODUCTION AND REVIEW OF PREVIOUS WORK.

During the investigation of asparagus rust in California, two publications have already been issued by this Station—Circular No. 9, "Report on Asparagus Rust Investigation," and Bulletin No. 165, "Asparagus and Asparagus Rust in California." Circular No. 9, published at the close of the first season's work, presents particularly some observations of considerable practical value upon the relations between the occurrence of the rust and the peculiar features of the California climate, showing how a great deal may be done to check the disease by simple cultural practices requiring no special application or treatment. Various other matters concerning the relation of the crop to the disease also receive attention in this circular.

Bulletin No. 165 aims to give quite a complete account of the culture of asparagus in California, particularly in relation to the rust. The nature and effects of the disease are described at length, together with a full account of two years' experiments in the prevention or control of the rust by various methods of treatment, bringing the work up to the close of the season of 1904. In its treatment of the nature and mode of development of the fungus causing the disease this latter bulletin is intended to be fairly complete and final, that side of the problem having been worked out quite fully under the conditions existing in all portions of the State where asparagus is extensively cultivated. The nature of the disease, and its relation to natural conditions, seem to require no further investigation at present in California.

In regard to methods of treatment for the control of the rust it may fairly be said that up to the time of the appearance of the disease in California nothing effective and satisfactory had been developed in other portions of the country previously affected. Considerable effort had been made in this direction by a number of State Experiment Stations, but the difficulties of the problem were great. The cause of the disease and its general nature were well understood. Being of a

fungous origin, spraying the plant with fungicides was the usual line of treatment resorted to, and not without more or less success.

Two difficulties in particular, however, kept such methods from ever becoming completely satisfactory or permanently successful. The earliest experimenters who attempted to find means for controlling the rust soon recognized the first of these difficulties. Working with the Bordeaux mixture and other similar liquid sprays, they found it impossible to cover the smooth, glossy surface of the plant with a uniform coating of these substances, on account of the tendency of the fungicide to gather into drops. Some effect in favor of the treatment could be seen, but not enough to cover the expense or save the beds from severe injury. Sirrine, of the Geneva (New York) Station, overcame this difficulty quite successfully by the addition of resin soap to the spray liquid, by which means asparagus tops could be thoroughly covered with the Bordeaux mixture. This again, however, on account of the rapid and continual development of the asparagus tops, proved insufficient. Unless sprayed every few days throughout a long season the fields soon outgrow the application and succumb eventually to the destructive rust.

To control the disease at all well with the resin-Bordeaux mixture, thorough spraying at least once a week was found necessary—a course which is impracticable on account of the expense, and impossible in the large California fields on account of the slowness of the operation and enormous amount of liquid which would have to be hauled about the fields. In the work of Sirrine a special spray-outfit was devised for the purpose, and at least one machine for asparagus spraying is on the market, but the expense and time required to keep down the rust at all completely by resin-Bordeaux spraying are so great that growers generally have given up this treatment as being out of the question except in a very small way.

In California the rust problem soon resolved itself into two somewhat distinct branches—that of the districts represented by Milpitas and Sacramento City, and that of the River district. The former asparagus sections are characterized as districts composed of numerous small holdings (5 to 100 acres), with rows planted close together (5 to 7 feet), and subject to considerable dew in summer. The River section has large individual plantings (100 to 1,000 acres), with rows 8 to 10 feet apart, and a dry, windy climate in summer. The question of rust control proved quite different in these two sections.

At the beginning of the present work in California, spray methods such as had been used in the Eastern States were tested quite thoroughly, in order to leave nothing undone which might be of value to the asparagus growers of this State. During the seasons of 1903 and

1904 spraying experiments with Bordeaux mixture, resin-Bordeaux, and other copper sprays were carried on at Milpitas, Sacramento, and various points in the River section. The results were practically the same as those obtained in other states. The amount of rust could be kept down by very frequent applications, but even at best the disease could not be controlled thoroughly enough to prevent severe injury, and the expense and time required to obtain even indifferent results were too great to make the treatment practical or bring it into general use. The tops could not be kept covered with copper sprays thoroughly enough to prevent the development of the disease.

The idea then suggested itself that a "dust spray" treatment might obviate some of the difficulties of the liquid method, requiring less weight of material and allowing more rapid application. Various mixtures of this sort, composed of pulverized bluestone and other copper salts mixed with lime, were therefore prepared and applied to asparagus in various ways and at different places. The results with these copper-dust sprays in controlling the rust were about the same as with the liquid sprays: not sufficient to make the treatment a satisfactory one. Some effect could be obtained, but not enough to save the crop or pay for the expense.

Discovery of Effects of Sulfur.—In the experiments with dust sprays during the season of 1903, it was found, quite unexpectedly, that dry sulfur applied to asparagus tops had a decided effect in preventing the development of rust. In these experiments rows dusted with dry sulfur several times during the season became much less rusted than any others. So promising did this appear that such treatment was urged upon growers for 1904, and over 100 tons of sulfur was used in the State upon asparagus during that season. It may frankly be said that much of this was wasted or applied without effect. Information was lacking as to the proper time and methods of application, the best kind of sulfur to use, how much to put on, and other practical details. Some expected too much of the treatment, applying a small amount of sulfur in a careless manner after the rust was well started, and then being disappointed by their poor success. Experience with the treatment was also not uniform in all the different asparagus districts. A full report of the experience of that year will be found in Bulletin No. 165, and need not be repeated here.

The most encouraging feature of the season's work was the success of the growers at Sacramento, who developed an original modification of the treatment, which gave absolute control of the rust in the best-treated fields, though it was abundant on all sides in neglected beds. Their treatment consisted in spraying with Bordeaux mixture, then sprinkling

on dry sulfur by hand while the tops were still wet. This was done, first, within three weeks from the time that the tops came up after cutting stopped, repeated in the latter part of July, and followed by an application of sulfur alone about a month later. This method, where fully carried out, entirely prevented the development of any rust during the whole season, and was certainly the most effective asparagus rust treatment ever demonstrated anywhere. Progress was also made during the season in developing means for applying sulfur, and in other details of this method of treatment. General experience demonstrated thoroughly—

That sulfur would keep the rust in check, if properly applied.

That for satisfactory results the first application must be made before any rust appears.

That the sulfur must stay on the tops and cover them quite thoroughly, in order to do much good.

Improper application in regard to the last two principles accounted in almost every instance for failure of the treatment.

Sulfur in Liquid Sprays.—The success of the dry-sulfur treatment led, in 1904, to some experiments with liquid-sulfur sprays, in order to broaden the scope of the work. It was found that a spray mixture made by dissolving sulfur in caustic soda, with the addition of resin or whale-oil soap, had some advantage in effect over resin-Bordeaux, though open to some of the same objections.

(See Bulletin No. 165, for account of all work up to this point.)

New Information Gained in Season of 1905.

The present bulletin presents new information in regard to asparagus rust treatment, obtained from the practical work of various growers during the past season, and from some special observations and experiments made in connection with Mr. Wm. Boots, Jr., who has been the mainstay of this work from the beginning. It seemed most necessary to determine in particular the following points: number of times necessary to sulfur, best times for application, how much sulfur to use, what kind of sulfur is best for the purpose, and how to treat the fields in the River district where there is very little dew in summer and the rust appears late in the season. The procedure and results in a few typical cases may be described as covering these points.

EXPERIENCE AT BOOTS RANCH, MILPITAS.

Asparagus cutting stopped at Milpitas about the first of July. Rust was less abundant than usual on uncut tops early in the season, but developed very vigorously after the beds grew up. In the Boots field

special efforts were made to keep down wild growth about the edges, which in previous years had caused a large amount of infection early in the summer. This had a very beneficial effect, giving all portions of the field a chance to develop equally, except one corner which bordered on a badly rusted field. After the end of the cutting season and the usual plowing and cultivation, the field was irrigated, in order to start up as vigorous a growth of tops as possible. About August 1st heavy dews occurred, and the first sulfuring was started. Using the seed-sower arrangement devised by Mr. Boots, going in every fifth row (seven feet apart), 70 sacks (110 pounds) of sublimed sulfur were

FIG. 1. Seed-sower, as adapted for applying sulfur.

put onto the 75 acres, in three mornings. About three weeks later (August 20 to 25), a second application was made. At this time, going in every third row, 60 sacks of sulfur were put on. Mr. Boots had, in the meantime, improved on the machine somewhat, principally in the sheet-iron hood over the vent, which threw the sulfur more downward into the rows, thus producing a saving in material. After another three weeks (September 12 to 15) the third and last sulfuring was made, using 50 sacks of sulfur. Mr. Boots had still further improved upon his machine, by broadening the hood and curving it over more on the sides than is shown in Fig. 1, with radiating flanges set in on the under side to equalize the spreading of the sulfur and confine it somewhat

to the three rows of asparagus. The sower was also set over to the middle of the bed, and run by a long shaft with chain gear on both

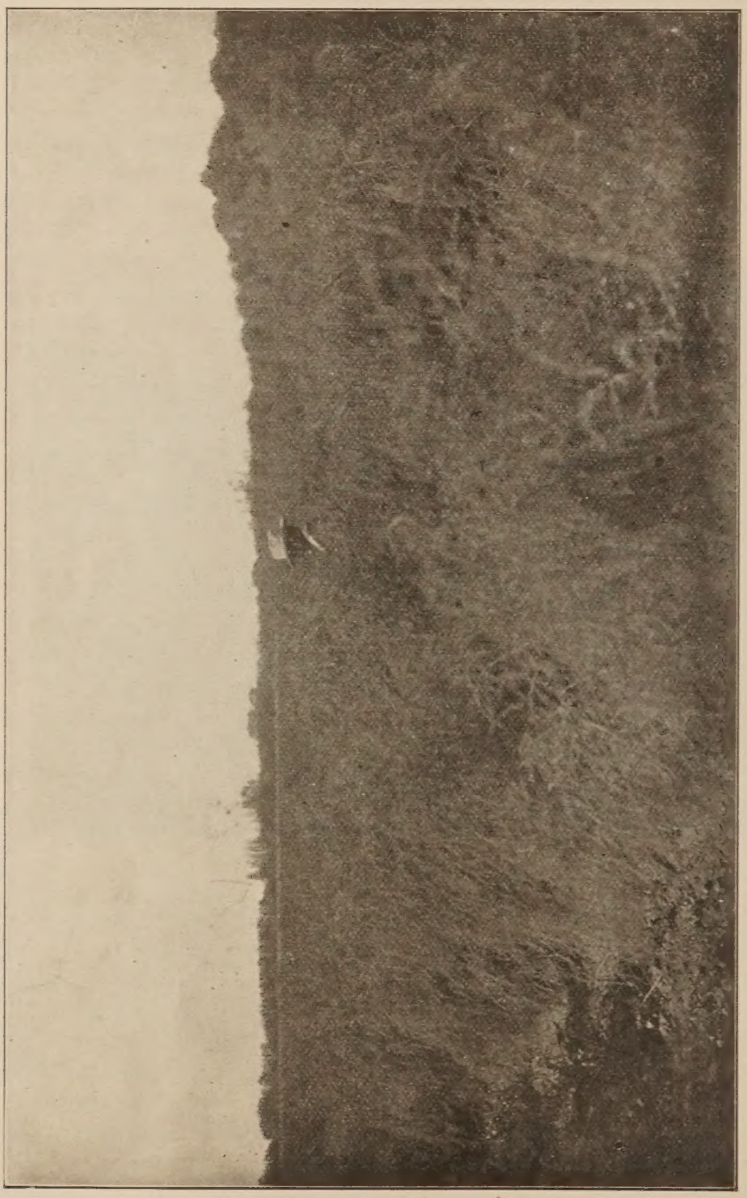

FIG. 2 Field of asparagus which received sulfur treatment. (Photographed October 20.)

wheels. This difference is shown by comparing Fig. 1 with Fig. 39 of Bulletin No. 165. The field was heavily irrigated and well cultivated

during the summer, in order to strengthen and force the growth as much as possible, irrespective of rust treatment.

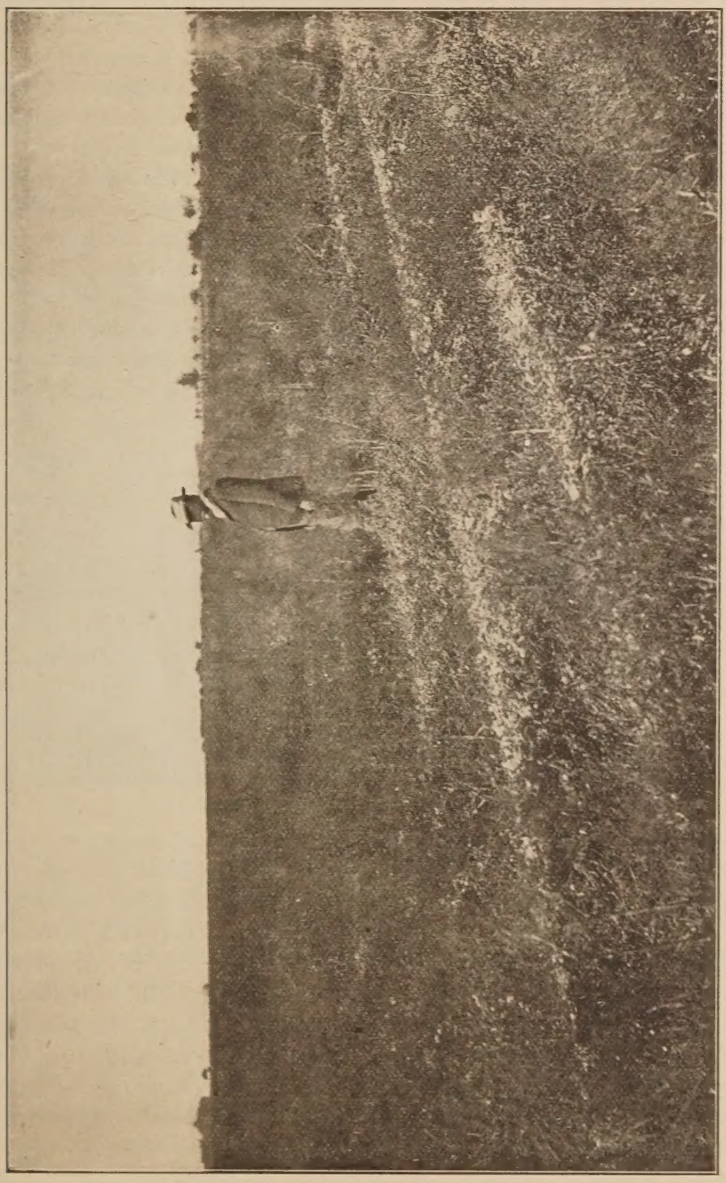

FIG. 3. Field which received no treatment, adjoining that in Fig. 2.

Results.—The results of Mr. Boots's work can be most easily indicated by a comparison of Figs. 2 and 3. Fig. 2 shows the growth in the

sulfured field, taken on October 20, while the other picture was taken on the same day in a field separated only by a fence from the first, of similar age and on similar soil. All untreated fields in the neighborhood were badly rusted early in September and the tops black and dead in October, when these pictures were taken. As shown in Fig. 3, there was scarcely any sign of asparagus left on the ground except a few blackened, stunted stalks. The rust was never worse anywhere in its history than at Milpitas this season. The Boots field made a fine growth, the best in years from the testimony of all local observers, and remained green until the normal end of the season, except for some yellowing from insect attacks. There was not enough rust in the field to show any effect upon the tops, except in one corner, next the field shown in Fig. 3. This was started somewhat before sulfuring commenced, and was enormously exposed to infection. The attack was not severe even there, and did not spread out into the field. The tops made a good growth, even in the worst part. The condition of the field as a whole was equal to that shown in the figure.

Expense.—The cost of this treatment amounted to about $425 for sulfur, and $25 for labor, or $6 per acre for the season's work on 75 acres. From the season's experience the sulfur bill can be reduced to $300 in the future.

Mr. Boots also grew a seed-bed during the season, producing as fine a lot of young plants as one often sees. From the time the seedlings appeared above ground until fall, he kept the rows well sprinkled with sulfur, and succeeded in keeping out all but a trace of rust during the season, the plants making a splendid growth. This was probably the only bed of plants grown successfully in that section since the rust first started.

EXPERIENCE OF R. S. BARBER, MILPITAS.

Mr. Barber, who has nearly the same acreage of asparagus as Mr. Boots, is another progressive grower in the Milpitas district. The treatment and condition of his fields previous to 1905 have been alluded to in Bulletin No. 165. Mr. Barber's method of applying sulfur was somewhat different from that of Mr. Boots. He had made the machine shown in Fig. 4, a high-bodied, two-wheeled truck, with a blacksmith's centrifugal blower worked by hand, and a sheet-iron hopper, from which the sulfur, as it falls from the bottom into the pipe, is blown through the three arms, each opening over an asparagus row. The man who runs the bellows also turns a stirrer in the hopper, which pulverizes the sulfur and keeps the supply running down into the outlet. Several of these machines have been made locally for asparagus growers, and one of the "dust sprayer" manufacturing firms has attempted an asparagus duster along somewhat similar lines, using one of their

machines with a cog-wheel gear on the wheel, and pipes behind for treating three rows. So far as the writer is informed, Mr. William Meek was the originator of this idea.

This machine will not throw nearly the amount of sulfur put on by the seed-sower used by Mr. Boots, and is open to objection on that point. Its greatest capacity produced only a dribble of sulfur on each row. On the other hand, less sulfur was required by this method for one application, as it all went on the rows, and the machine could not be made to spread a large amount, like the seed-sower. The latter can be adjusted to throw any amount, small or great, but scatters the material more than the pipe arrangement. In the case of the latter,

FIG. 4. Sulfur blower for treating asparagus.

frequent applications were made by Mr. Barber during the summer—four or five in all—so that the total amount of sulfur used was fully as much or greater than that required in Mr. Boots's method. This field was irrigated and cultivated during the summer, and was never allowed to suffer in any way for lack of care.

Results.—Mr. Barber's results were fully as satisfactory as those of Mr. Boots. His asparagus made a beautiful, heavy growth, and remained green until late in fall, with no damage from rust. Nearby fields in all directions which received no treatment suffered very severely. Both these growers had every reason to feel satisfied with their efforts.

Other Milpitas growers used more or less sulfur on asparagus during the season, with results in every case proportionate to the efforts put

forth. The futility of sulfuring after the rust becomes well developed in the field was shown here again, as has been the universal experience.

SACRAMENTO EXPERIENCE.

The Sacramento growers had reason to feel that they had solved the problem of rust control from their experience of 1904, when the combination liquid-spray and dry-sulfur treatment gave absolute control of the rust. In 1905 almost all of them carried out the same line of treatment, and with results equal to those of 1904.

Mr. E. Rider used sulfur alone, as before, putting it on with a hand

FIG. 5. Outfit for treating asparagus by Sacramento method, consisting of pump and barrel on one-horse sled, one man to pump and drive, two to spray with liquid, and two to apply sulfur from buckets by hand.

blower on dewy mornings, and kept his fields green until late fall. The growers using the combination treatment made an improvement on their original method, adding whale-oil soap to the Bordeaux spray as recommended in Bulletin No. 165. This made a marked improvement in sticking the sulfur to the tops. Their method of work was that of 1904, using a one-horse sled between the rows, carrying a barrel and pump, one man pumping and driving, one or two spraying, and two following close behind with buckets of sulfur (which had first been sifted with a flour-sifter), sprinkling it on by hand. Figure 5 illustrates this method.

The work of O'Brien Brothers is a typical example of what was done at Sacramento. These growers sprayed and sulfured their beds between July 15 and 25, doing the work very thoroughly and carefully.

On their 15 acres of asparagus they used 22 sacks of sulfur. One month later (August 22) they put on about 40 sacks of sulfur alone, sprinkled on by hand on wet mornings (3 to 9 A. M.). Only these two applications were made by these and the other growers using the same method. It is also worth noting that 30 rows in the field received only the one treatment of soap-Bordeaux and sulfur in July, and nothing further during the season.

Results.—The results of this treatment were as good as in 1904, the rust control being practically perfect. The tops in untreated fields were

FIG. 6. Outfit for spraying asparagus with liquid spray.

killed early and completely, rust was active and abundant on all sides, but all the well-treated beds kept green and free from the disease. The 30 rows which had but one treatment were particularly examined by the writer, and found to be as free from rust as the rest of the field.

Some spraying with Bordeaux mixture done at Sacramento in 1905 had the usual result of affecting the rust only to a very slight extent. The Olsen fields at Sixteenth and Twenty-third streets, north of the railroad, were thoroughly sprayed by the present owners, who originated the outfit shown in Fig. 6 for the purpose. Straddling one row, with two men standing on the bridge behind spraying three rows with the double nozzles, and one man to pump and drive, this is the most useful

contrivance for spraying asparagus which the writer has seen. The outfit proved somewhat top-heavy, and would be improved by having the wheels farther apart.

A few of the Sacramento growers started the season by spraying with the Bordeaux alone, when the majority were both spraying and sulfuring. The result was thoroughly typical of all experience along this line. All the sprayed fields began to show rust abundantly, while those which had sulfur in addition, situated on all sides of the others, with only fences or roads between, kept clean (as before stated) all through the season. The growers who had used Bordeaux alone then made a heavy application of sulfur, and succeeded in preventing the rust from attacking the later growth, though this can not be counted upon under all circumstances. In these small fields with rows close together and very thick growth, a thorough treatment by hand gives better results than can be expected in working on a larger scale.

Most of the Sacramento growers have decided upon the following treatment for future use: Three weeks after cutting stops, start spraying with whale-oil soap and water (6 pounds to 50 gallons) and dust on 1½ sacks of sulfur per acre; one month later apply 2 sacks of sulfur per acre (on dewy mornings). This treatment, from two years' experience, is an absolute rust-preventive in that locality.

EXPERIENCE IN THE RIVER DISTRICT.

The study of rust control in the great island and river asparagus ranches has not reached the stage of completion attained at Milpitas and Sacramento. This is mostly due to the fact that it is still a question whether the cultural methods and ways of taking advantage of climatic conditions described in Circular No. 9 and Bulletin No. 165 are not sufficient to prevent any serious injury from rust in most of these regions. At such places as Jersey Island, Andrus Island, Grand Island, the Pearson District, and, to nearly the same extent, Bouldin Island, the rust may be so held in check by keeping down all early wild growth which would allow the fungus to start, and by keeping the fields exposed to the full drying effect of the prevailing wind, that expensive methods of fungicidal applications (sulfuring, spraying, etc.) have not yet been demonstrated to be necessary.

It is still a question in much of this region whether the slight attack of rust late in the season is of any serious consequence, and whether it is necessary or would be profitable to try to prevent it. It is an enormous undertaking to make any thorough application to these great fields of hundreds of acres. The sulfur treatment as practiced at Milpitas would be difficult, on account of the distance apart of the rows and absence of dew. Thorough preliminary spraying with a

liquid is not very attractive, unless extremely necessary, on account of the size of the fields. It is quite certain that one application, in August, of the Sacramento spray-sulfur treatment would control the rust sufficiently. Apparatus can be obtained or devised for doing this rapidly if it proves necessary, but the latter is still a question. Some experiments along this line were made at Vorden during the season, but owing to the late and slight development of rust were not conclusive. Some sulfuring was also done there and at Bouldin Island, in the latter instance with a seed-sower, but this was late in the season when the rust had already appeared and no very definite results were seen.

The situation, as it looks to the writer, is about this: At Milpitas and Sacramento the rust has been completely and practically controlled by the methods described. If not so checked the disease ruins the beds in a few years. The method in either case consists essentially in getting a good coating of sulfur on the tops before the rust appears and keeping it there through the rest of the season. On the river there is a doubt whether this is necessary. If so, practical means must be found for making the same application and doing it thoroughly, rapidly, and cheaply. It is simply a question of making the sulfur stick to the tops before the time when the rust usually appears.

EASTERN EXPERIENCE WITH SULFUR TREATMENT.

Since the beginning of this work in California, considerable interest has been displayed in the matter by asparagus growers in all parts of the country. In climates with rain in summer the writer has felt no faith in the success of the dry-sulfur treatment, but has suggested the possible value of liquid-sulfur sprays. Considerably to his surprise, however, Donner Brothers, large asparagus growers of Seabrook, South Carolina, who have kept closely in touch with this work, report good results from the use of dry sulfur. Mr. L. Donner, writing under date of September 23, 1905, says:

> We have made this summer experiments with various kinds of fungicides against asparagus rust, but principally with sulfur. We have applied the latter in varying quantities and at different times, and have found that if applied in time, about three weeks after the crop was over, and continued with two applications per month through June, July, and August, we can keep the rust out effectively. We have some beds now which do not show a sign of rust; others where we did not sulfur early enough or were treated with Sal Bordeaux, are badly rusted.

Again, October 23:

> We only applied sulfur in dry form, as we have come to the conclusion that application of spray of any kind is very expensive, and with our present labor almost impossible to apply thoroughly. We divided our fields into patches and gave different applications of sulfur on each, as follows: One piece we gave one application per month, another two applications, another one in June and July,

and one June, July, and August, while one piece was given an application after every rain. We found that it was absolutely essential to start early (that is, within three weeks after tops began to grow up), and found that we had to give more than one application for the first two or three months. When once the rust gets a hold it is impossible, or at least we found it so this year, to eradicate or stop it. Even in the pieces where we applied the heaviest doses of sulfur we find some traces of rust, especially at ends of rows. We also find that rust is developing as late as the present month, October, even in parts which we have kept clean of it all through the season. I expect this late rust can not do much if any harm, still we keep up the sulfur treatment and shall also give an application after the bushes are cut down. We have given all the way from 400 to 1,000 pounds per acre, and have applied from 50 to 170 pounds at a time.

From the results of these valuable experiments of Donner Brothers it seems possible that a practical dry-sulfur treatment might be developed, even in Eastern States with rain in the summer. We certainly commend the matter to the attention of growers and investigators in those states, giving the credit for this pioneer demonstration to those who so enterprisingly carried it out.

MACHINERY FOR APPLYING DRY SULFUR.

The outfits which growers have devised especially for this work are still in process of development and improvement, and can not fairly be compared or criticised. They are all doing the work, and are improving from year to year. For work on a small scale there is little choice of apparatus, except in regard to convenience, cost, etc. Anything which will put on sulfur in a dusty cloud will give successful results. Bellows and fan blowers of many different kinds, pepperbox-style shakers, shaking through a coarse sack, and simply sprinkling on by hand, have all been used successfully by different growers. Others, too, have made failures of all these methods. For larger work we have the seed-sower, the outfit such as Mr. Barber and others used, various large-sized dust-sprayers of different makes, and anything else which the ingenious mind may suggest. Some will do better work than others, but conditions vary in different places, and the best of them can easily be used in a totally ineffective manner. It is easy to throw sulfur into an asparagus field. To cover the tops thoroughly with a uniform coating is quite a different matter.

On general principles the seed-sower represents one type of machine, and the fan blowers with tubes another. The former throws out a tremendous cloud of dust, which penetrates everything and settles gently down upon the surface. This cloud, by hoods and flange chutes on the under side of the hood, can be considerably confined and directed toward the rows. The farther apart the rows the more difficult it becomes to cover more than one row thoroughly with the seed-sower. The fan blowers send out a small stream, which either shoots through the tops with considerable force, or, if carried through tubes, loses its force and

simply dribbles down upon the tops without spreading enough to cover one row thoroughly. This necessitates frequent applications.

These remarks apply only to the machines described as having been in use during the season. Another season will probably see all of them changed and improved more or less. Theoretically a contrivance with a tube to each row would be most economical, but other factors come in. Any practical machine must have a large hopper, into which a sack or more of sulfur can be emptied directly, and power and size enough to throw out a heavy dust-cloud into each row which it attempts to cover, and an arrangement for regulating the flow. It must be remembered that pure sulfur is heavier and less dusty than lime, which is the usual basis of dust sprays.

For sulfuring the large fields in the islands, if such treatment proves necessary, it appears to the writer that a seed-sower arrangement closely hooded in to cover one row only, or else a very large fan blower with pipes to two rows, will prove most desirable. The rows are too far apart to throw out the sulfur broadcast, and the smaller dust-sprayers will not throw sulfur enough for use in these fields.

Some of these practical questions can only be solved by the growers themselves or their mechanics. The writer would advise any one interested in the matter to go and see the different machines in the hands of those using them, and, if possible, study them in operation.

MANNER OF PUTTING ON SULFUR.

This, as repeatedly stated, is the essence of the whole matter. *The sulfur must go on in a dusty, smoky cloud, and form a covering all over the growth.* If the apparatus does not throw the sulfur properly, if the sulfur is too coarse, the tops too dry, or the wind too strong, or if any other condition prevents the proper result, the sulfur will probably be thrown away. If, therefore, a machine is used which throws but a small quantity, more frequent applications must be made. If there is no dew one must either wait for it or wet the tops with whaleoil-soap water. That kind of sulfur must be used which will stick on most readily. If rows are missed with the seed-sower it must take fewer at a time; and so every condition which works against ideal results must be met and overcome.

KIND OF SULFUR TO USE.

This important subject has received considerable attention since the last bulletin was issued. As stated there, powdered sulfur is on the market in three grades, disguised more or less by various brand and trade names. *Ground, pulverized,* or *flour of sulfur* is sulfur ore which has been more or less purified by melting and cooling, and then ground

in a mill. *Sublimed sulfur* is that which has been purified and brought into extremely fine, flaky particles by the process known as sublimation. *Flowers of sulfur* consists of the very finest, lightest portion obtained in sublimation.

It was soon recognized in using sulfur on asparagus that there is a great difference, both in effect and mechanical action, between a coarse, sandy, ground sulfur, and the sublimed or flowers, though the first is considerably cheaper. Bulletin No. 165 urged the use of the better grades, but this can be much more strongly stated from the results of definite tests made this season. In coöperation with Mr. Boots, using his seed-sower machine, tests were made to determine the covering and

FIG. 7. Sacks (110 pounds each) of flowers of sulfur, sublimed and ground sulfur (from left to right).

sticking capacity of equal weights of high-grade ground, sublimed, and flowers of sulfur. Fig. 7 shows a sack of each—the flowers at the left, the ground at the right. These three sacks of sulfur represent a value, or cost, of $45 per ton, $40, and $33 (f.o.b. San Francisco), or about $2.50 per sack for the flowers, $2.20 for the sublimed, and $1.90 for the ground. It is readily seen that though equal in weight, the *bulk* is directly proportionate to the cost. The first test was made by putting on a sack of ground sulfur with the sower regulated at a certain sized opening, then one sack of each of the others at the same opening, noting the area or number of rows covered by each.

The sack of ground sulfur ($1.90) covered.....1⅝ acres.
The sack of sublimed sulfur ($2.20) covered.....1½ acres.
The sack of flowers of sulfur ($2.50) covered.....2 acres.

The cost per acre was therefore $1.38 with ground sulfur, $1.47 with sublimed, and $1.25 with flowers.

In this test, using the same sized opening in the machine for all, very little of the ground sulfur was left in sight upon the tops, while the others formed a heavy, very prominent coating. The finer sulfur came out of the machine more rapidly than the ground, so that the difference in the amount left on the tops was much greater than that in the acreage covered. This being impossible to measure, another test was made, directing the operator to vary the flow of sulfur by trying to put on an equal covering of each kind, letting each sack go as far as it would. In this way:

The sack of ground sulfur covered.....1½ acres.
The sack of sublimed sulfur covered.....1⅞ acres.
The sack of flowers of sulfur covered.....2½ acres.

Even in this test the flowers, spread over nearly twice as much area as the ground sulfur, showed at least twice as much remaining on the tops as the latter, which was also greatly inferior in this respect to the sublimed.

The cost basis figures this time, ground sulfur $1.30 per acre, sublimed $1.17 per acre, and the flowers $1.00, at the same time leaving twice as much sulfur on the tops with the better kinds, and in a light, clinging, easily volatilized condition. The difference is not alone in fineness, for the sublimed and flowers cling even to a smooth, dry surface to a considerable extent, like dust to a mirror, while a large amount of the ground sulfur falls off like sand, even from wet tops.

There can be no possible question that the finest, highest-priced flowers of sulfur is by far the cheapest and most effective for use on asparagus. But great care must be used to get the real thing.

NUMBER AND TIME OF APPLICATIONS, AND AMOUNT OF SULFUR.

Enough has already been said to cover these points. The important thing everywhere has been shown to be, *to get a good coating of sulfur on the tops just before the rust is due to appear.* At Milpitas and Sacramento, and in any place where there is considerable dew in summer, this makes the first application necessary as soon as the tops get much growth, or in about three weeks after cutting stops. A second application one month later, and a third after another month, using one half a sack of *flowers* of sulfur per acre each time, will give good results. This year's experience indicates that if all wild growth at the edges of the fields is kept down closely, and there is no rusty field close by, two applications (the first and the second) are sufficient, even at Milpitas. At Sacramento it has already been stated that one heavy sulfuring combined with a soap spray was the only treatment used on part of a field, with results equal to those of two applications. Others

have used a larger number of light applications with equally good results.

The point of supreme importance is to begin early enough and do the work thoroughly.

TREATMENT OF YOUNG BEDS.

The poorest results from the dry-sulfur treatment, even when carefully made, have been in the case of young beds from one to three years of age, in which the tops have not yet grown thickly enough together to catch and hold the sulfur well. In such cases the writer would advise a thorough treatment by the Sacramento method, spraying with whale-oil soap, following with an application of sulfur by hand. In this way the growth can be thoroughly covered with sulfur, which will not be easily shaken or even washed off. A few treatments of this sort during the season will be found effective.

It is the writer's opinion that growers with beds of any age that are not too large, will do well to follow this method of rust control. It has been absolutely effective wherever tried.

KEEPING DOWN WILD GROWTH.

Each year's experience shows more and more that nothing is of so great value in rust control in California as the close, thorough rooting-out of every stalk of wild asparagus growing near the fields. The stalks must not be simply clipped off some distance above ground or a few left because they are few. One rusty stalk at the edge of the field, even if only a few inches high, can make several weeks' difference in the appearance of the rust.

IRRIGATION, CULTURE, ETC.

All that has been said along these lines in previous publications is still to be strongly emphasized. The best of rust treatment can not make up for lack of care.

ASPARAGUS CONDITIONS IN 1905.

The crop of the season in California was a very disappointing one to growers and canners. Many fields have been badly injured by rust, but aside from these effects the cold, wet cutting season, following unseasonably warm weather in February, cut down the crop severely in every district. In fields protected from rust, or in districts not severely attacked, the tops have made a better growth than for several years, and the prospect for next year's (1906) crop is excellent.

Rust during the season was as active as ever; a considerable acreage

of asparagus, ruined by the disease, will soon be plowed out, and much more has suffered severely. On the river the unusually long rainless season held back the rust until October, and kept it from becoming severe in that section.

One noticeable feature of this year's growth has been a premature yellowing and dying of many stalks, without regard to rust. This has been commonly ascribed to the attacks of centipedes in the soil, minute creatures producing an injury which was ascribed to wire-worms in Bulletin No. 165. In some cases examined by the writer, the asparagus miner (*Agromyza simplex* Loew) was very abundant in the stems of the yellow stalks.

In the Atlantic States the rust has been unusually prevalent in 1905, according to reliable reports, showing that the epidemic there has by no means passed.

Of interest as a matter of record is the report of the occurrence of asparagus rust in Arizona, by Mr. J. Thomas Brown of Prescott, who writes that they have noticed the disease on beds in the river bottom there since 1903.

CALIFORNIA PUBLICATIONS AVAILABLE FOR DISTRIBUTION.

REPORTS.

1896. Report of the Viticultural Work during the seasons 1887-93, with data regarding the Vintages of 1894-95.
1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.
1898. Partial Report of Work of Agricultural Experiment Station for the years 1895-96 and 1896-97.
1900. Report of the Agricultural Experiment Station for the year 1897-98.
1902. Report of the Agricultural Experiment Station for 1898-1901.
1903. Report of the Agricultural Experiment Station for 1901-1903.
1904. Twenty-second Report of the Agricultural Experiment Station for 1903-1904.

BULLETINS.

Reprint. Endurance of Drought in Soils of the Arid Region.
No. 128. Nature, Value, and Utilization of Alkali Lands, and Tolerance of Alkali. (Revised and Reprint, 1905.)
131. The Phylloxera of the Vine.
133. Tolerance of Alkali by Various Cultures.
135. The Potato-Worm in California.
137. Pickling Ripe and Green Olives.
138. Citrus Fruit Culture.
139. Orange and Lemon Rot.
140. Lands of the Colorado Delta in Salton Basin, and Supplement.
141. Deciduous Fruits at Paso Robles.
142. Grasshoppers in California.
143. California Peach-Tree Borer.
144. The Peach-Worm.
145. The Red Spider of Citrus Trees.
146. New Methods of Grafting and Budding Vines.
147. Culture Work of the Substations.
148. Resistant Vines and their Hybrids.
149. California Sugar Industry.
150. The Value of Oak Leaves for Forage.
151. Arsenical Insecticides.
152. Fumigation Dosage.
153. Spraying with Distillates.
154. Sulfur Sprays for Red Spider.
155. Directions for Spraying for the Codling-Moth.
156. Fowl Cholera.
157. Commercial Fertilizers.
158. California Olive Oil; its Manufacture.
159. Contribution to the Study of Fermentation.
160. The Hop Aphis.
161. Tuberculosis in Fowls. (Reprint.)
162. Commercial Fertilizers. (Dec. 1, 1904.)
163. Pear Scab.
164. Poultry Feeding and Proprietary Foods. (Reprint.)
165. Asparagus and Asparagus Rust in California.
166. Spraying for Scale Insects.
167. Manufacture of Dry Wines in Hot Countries.
168. Observations on Some Vine Diseases in Sonoma County.
169. Tolerance of the Sugar Beet for Alkali.
170. Studies in Grasshopper Control.
171. Commercial Fertilizers. (June 30, 1905.)

CIRCULARS.

No. 1. Texas Fever.
2. Blackleg.
3. Hog Cholera.
4. Anthrax.
5. Contagious Abortion in Cows.
7. Remedies for Insects.
9. Asparagus Rust.
10. Reading Course in Economic Entomology.
11. Fumigation Practice.
12. Silk Culture.
No. 13. The Culture of the Sugar Beet.
14. Practical Suggestions for Codling-Moth Control in the Pajaro Valley.
15. Recent Problems in Agriculture. What a University Farm is For.
16. Notes on Seed-Wheat.
17. Why Agriculture Should be Taught in the Public Schools.

Copies may be had by application to the Director of the Experiment Station, Berkeley, California.